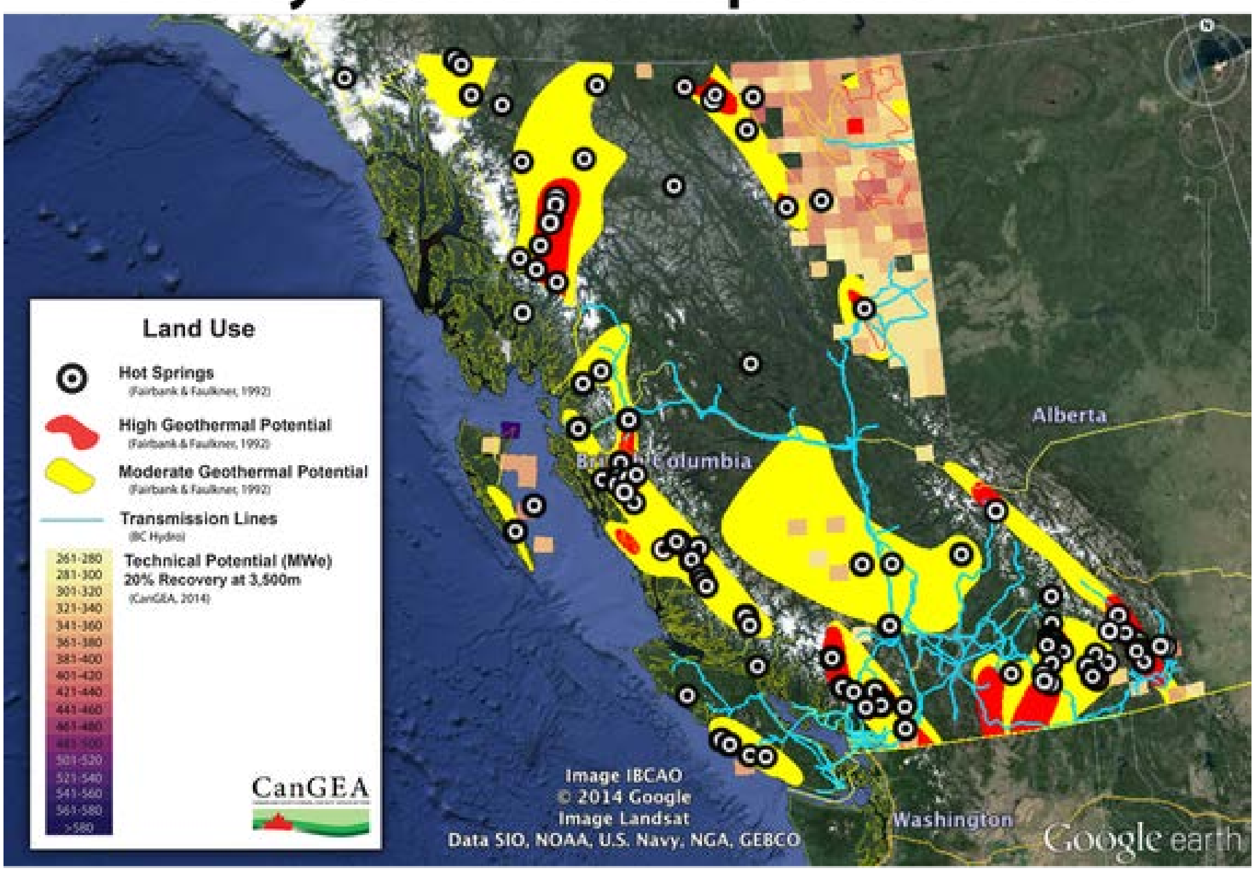
CanGEA

CANADIAN GEOTHERMAL ENERGY ASSOCIATION

Response to the British Columbia Utilities Commission Site C Inquiry Preliminary Report

October 10, 2017

Priority Geothermal Exploration Areas



Canadian Geothermal Energy Association (CanGEA)

CanGEA is the collective voice of Canada's geothermal energy industry, and provides a forum to promote geothermal energy development in Canada and abroad. As a non-profit industry association, CanGEA represents the interests of its member companies, with the primary goal of unlocking the country's tremendous geothermal energy potential.

We are asking the Commission to approve our application for intervener status, so that we can fully participate in the inquiry proceedings and make application for a cost award in accordance with the Commission’s Rules of Practice and Procedure.

CanGEA meets the criteria for standing to participate as an intervener in this proceeding. CanGEA’s interests, and the interests of its members, who are existing or potential developers of geothermal electricity in BC, will be directly affected by the Commission’s findings on Section 3(b)(iv) of the Inquiry’s Terms of Reference, pertaining to what, if any, other portfolio of commercially feasible generating projects could provide similar benefits to ratepayers at similar or lower unit energy cost as the Site C Project. CanGEA qualifies both as an interested party (as per Section 3(d) of the Inquiry’s Terms of Reference) and a source of expert advice (as per Section 3(f) of the Inquiry’s Terms of Reference) that the Commission must and may consult, respectively. CanGEA therefore respectfully makes this submission and requests the Commission grant CanGEA intervener status and the ability to apply for a cost award.

Our members are the visible embodiment of our commitment to the development and production of clean, renewable and sustainable geothermal energy. It is through our collective desire and dedication that we continue to achieve progress in this industry towards making geothermal energy a reality in Canada.

It should be noted that in addition to CanGEA member projects there are two other development projects in British Columbia by companies who are not CanGEA members but also are trying to develop geothermal resources. While CanGEA acts in the interests of its members, and will mention its member projects in this submission by way of example, there are some attempts at development ongoing outside of what is being undertaken by CanGEA members.

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In the Preliminary Report on Site C, released on September 20, 2017, the Panel posed specific questions to BC Hydro and other parties. In this follow-up to our submission of August 30, 2017, CanGEA presents our answers to these questions, as well as responses to recent submissions by BC Hydro concerning geothermal.

Response to BC Hydro Submission of October 6, 2017:

CanGEA notes BC Hydro's estimated unit energy cost for geothermal of $120/MWh as stated in section 44.0 (page 8 of 10) in BC Hydro's submission. CanGEA appreciates BC Hydro's economic model input and invites BC Hydro to work with CanGEA's members to derive an updated Levelized Cost of Electricity (LCOE).

CanGEA also notes BC Hydro's statement of their approach using "levelized costs that apportion project costs to the portfolios based on the number of years a project is included in the portfolio." This occurs in section 49.0 (page 1 of 3) of BC Hydro's submission. CanGEA concurs with BC Hydro's levelized cost approach.

However, CanGEA disputes the assignation of a 20-year project life to geothermal resources in section 52.0 (page 1 of 1). CanGEA members' projects presented herein have been modelled on a 30-year lifespan. Refer to Appendices F & G to this submission. In the United States[1] and New Zealand,[2] similar geothermal equipment has been in operation for more than 50 years and continues to operate. In Italy there is a field that has been in operation for more than 100 years. CanGEA suggests that the Commission recommend BC Hydro assign to geothermal resources a project lifespan of at least 50 years, given this information.

[1] Calpine Corporation. *Historic Timeline- The Geysers: A Very Special Place*. Retrieved October 10, 2017, from geysers.com: http://www.geysers.com/history.aspx

[2] Contact. *Our Powerstations*. Retrieved October 10, 2017, from Contact.co.nz: https://contact.co.nz/aboutus/our-story/our-powerstations

Response to BC Hydro Submission of October 5, 2017:

In their submission to the Commission on October 5, 2017, BC Hydro made several unexpected statements regarding the viability of geothermal in the alternative portfolio proposed by Deloitte, in their report to the Commission of September 8, 2017.

BC Hydro, on pages 4-5 of the Executive Summary of their submission, stated the following:

> "Deloitte has contemplated that low cost geothermal resources would represent a large portion of BC Hydro's total resources by 2036. In effect, Deloitte assumes that BC Hydro would build more geothermal resources than currently exist in Iceland, which has the highest geothermal potential in the world due to advantageous environment conditions that do not exist in BC. Given that exploration to date in BC has not identified any viable geothermal resources, there is a reasonable prospect that ratepayers would have to pay for higher cost resources to make up for geothermal when it does not materialize."

CanGEA offers the following response to this statement.

"More Geothermal Resources Than Currently Exist in Iceland":

The use of Iceland as an example by BC Hydro is hardly a relevant comparison to the BC circumstance. Iceland has a population of 334,252[3] and almost none of Iceland's land mass is inhabited. Furthermore, Iceland has limited heavy industry. With around 5,800MW of estimated geothermal potential, Iceland has only developed what they needed from their geothermal resources to meet their population and industry demand.

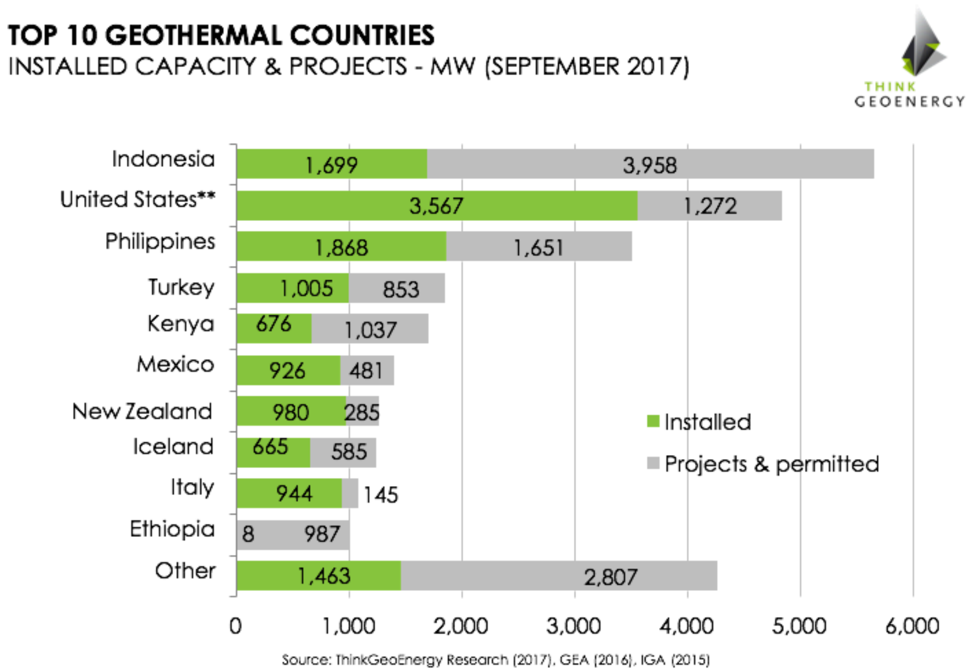
An appropriate comparison for BC Hydro to make would be with the United States, which, making use of geology very similar to British Columbia, have installed 3,567 MW of geothermal capacity, with 1,272 MW more currently in development. Observe Chart 1 (below).

The United States further has approximately 30,000 MW as yet undeveloped. Scientists with the US Geological Survey (USGS) recently completed an assessment of geothermal resources in the United States. The assessment indicates that the electric power generation potential from identified geothermal systems is 9,057 MWe, distributed over 13 states. The mean estimated power production potential from undiscovered geothermal resources is estimated by this survey at 30,033 MWe. Additionally, another estimated 517,800 MWe could be generated through implementation of technology for creating geothermal reservoirs in regions characterized by high temperature, but low permeability, rock formations.[4]

[3] The World Bank. (n.d.). *Population Total: Iceland*. Retrieved October 6, 2017, from The World Bank: Data: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=IS

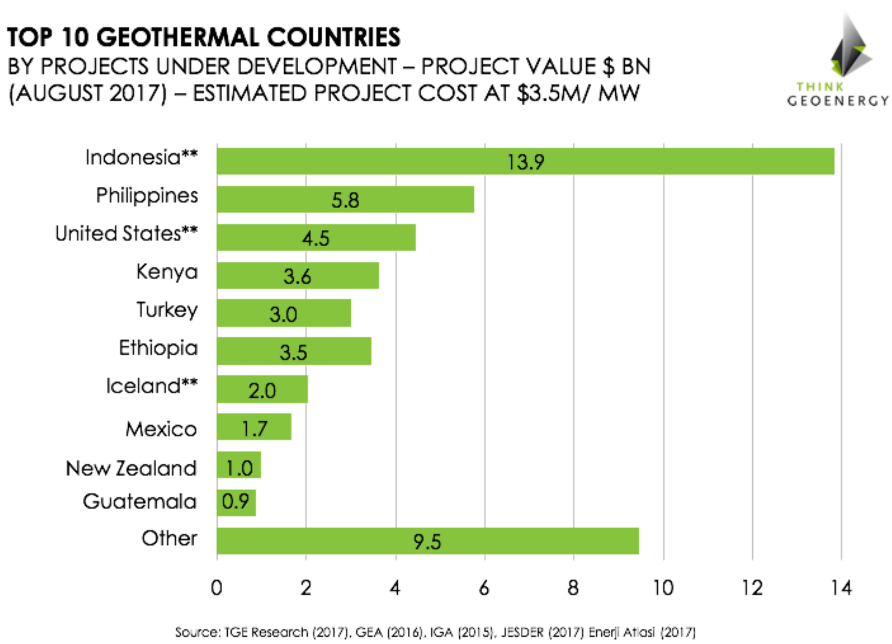
[4] Williams, Colin F., Reed, Marshall J., Mariner, Robert H., DeAngelo, Jacob, Galanis, S. Peter, Jr., 2008, Assessment of moderate- and high-temperature geothermal resources of the United States: U.S. Geological Survey Fact Sheet 2008-3082, 4 p.

Chart 1:



The 1,272MW of base load geothermal power presently being developed in the United States is being developed at a cost of USD$4.5B, as the Chart 2 (below) shows:

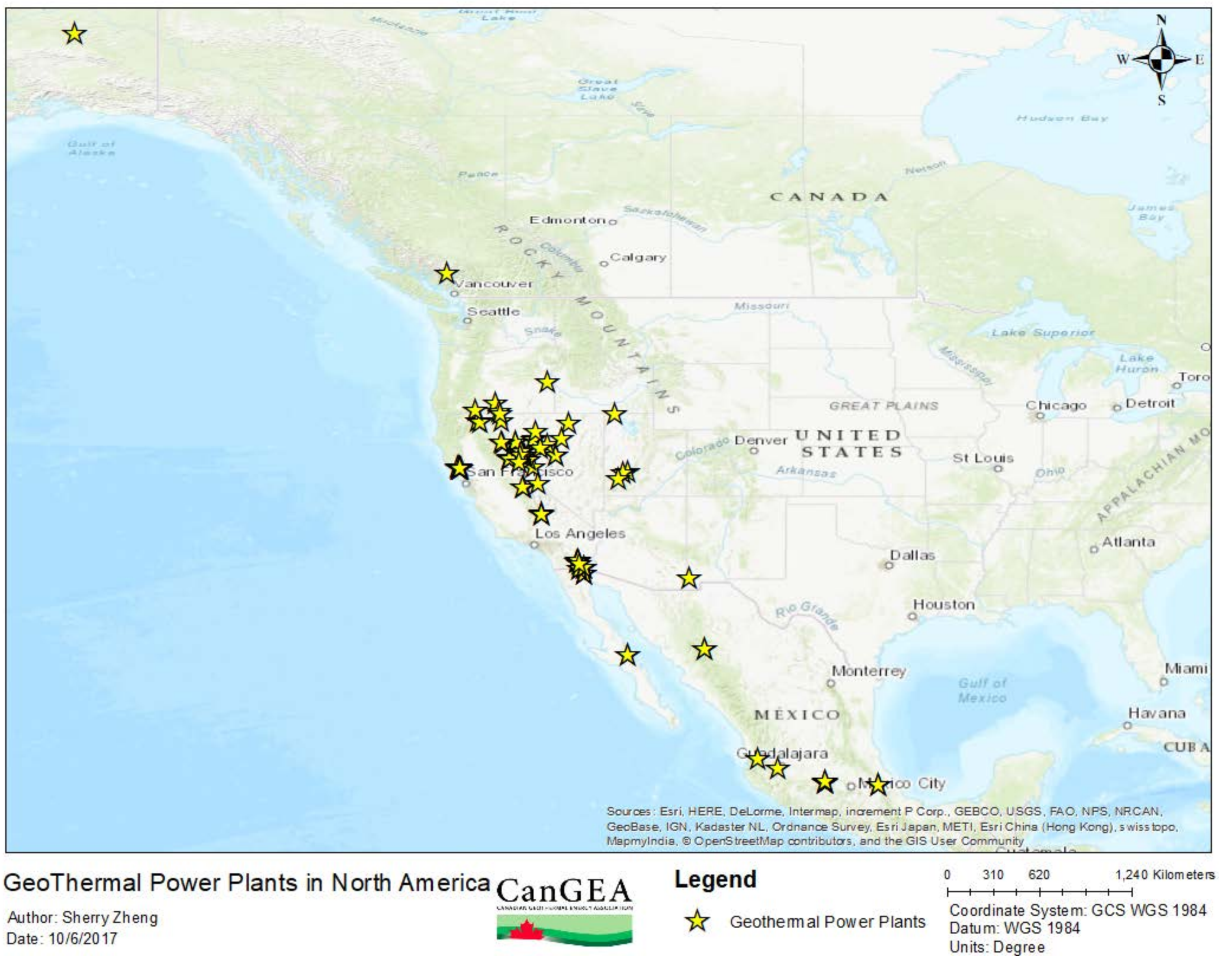
Chart 2:



It is worth noting that the United States' 1,272 MW of in-development geothermal electricity is coincidentally comparable to the estimated production capacity of the Site C Project (1,100 MW) at a capital cost far lower than the Site C Project, even when the currency exchange rate is taken into consideration. There is also the capacity factor to take into consideration given Site C's capacity factor is 53% while geothermal electricity is base load (95% capacity factor).

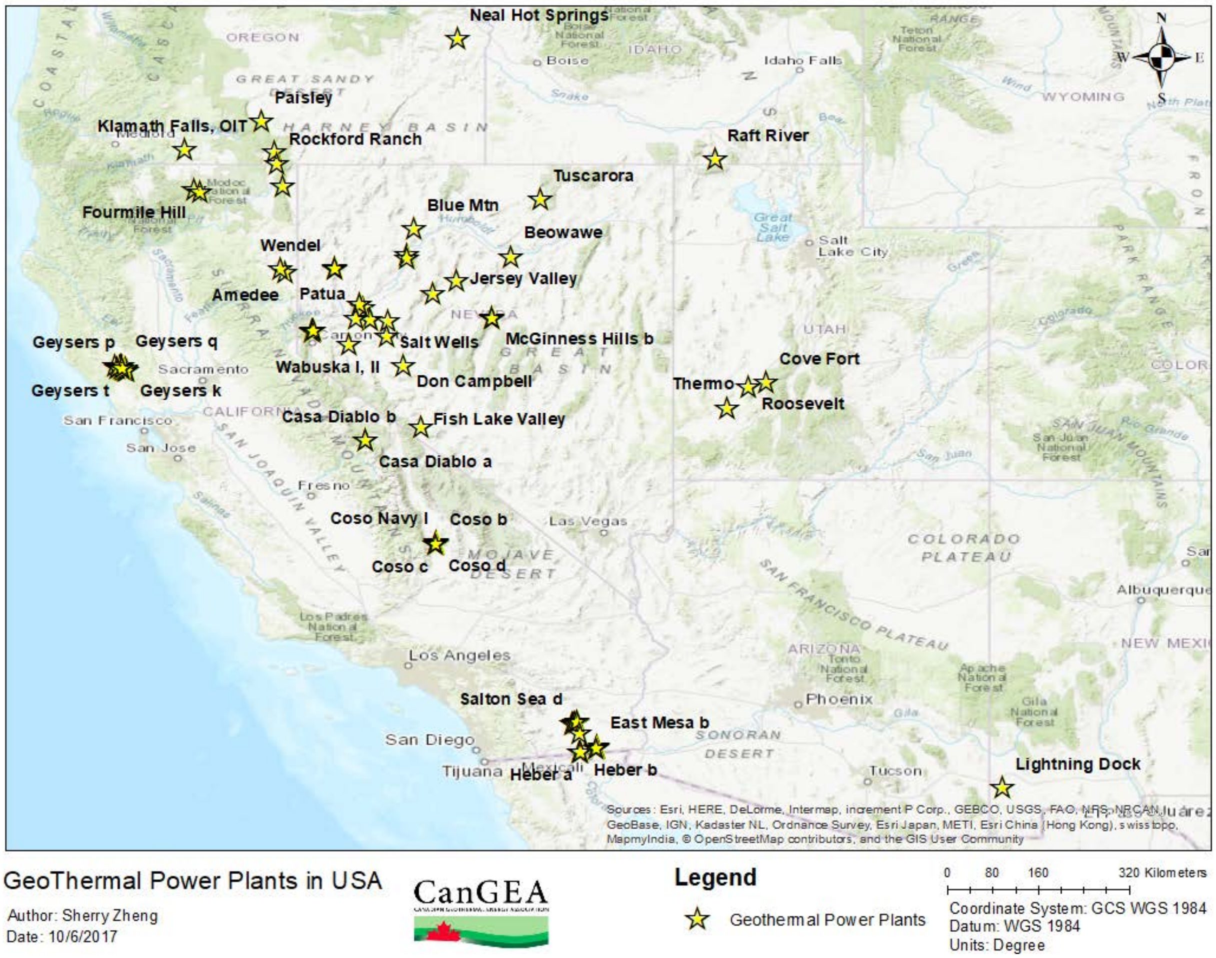
Below is a map (Map 1) of North America's geothermal power plants, including the trial completed at Meager Creek, BC.

Map 1:



Zooming in on this map (Map 2) reveals the high concentration of geothermal power plants in the Western United States, in a geological setting similar to British Columbia. Not only do these maps suggest the vast production capacity as yet untapped in British Columbia, it also shows how, when government collaborates with industry and is committed to developing geothermal power, a vast and productive industry results.

Map 2:

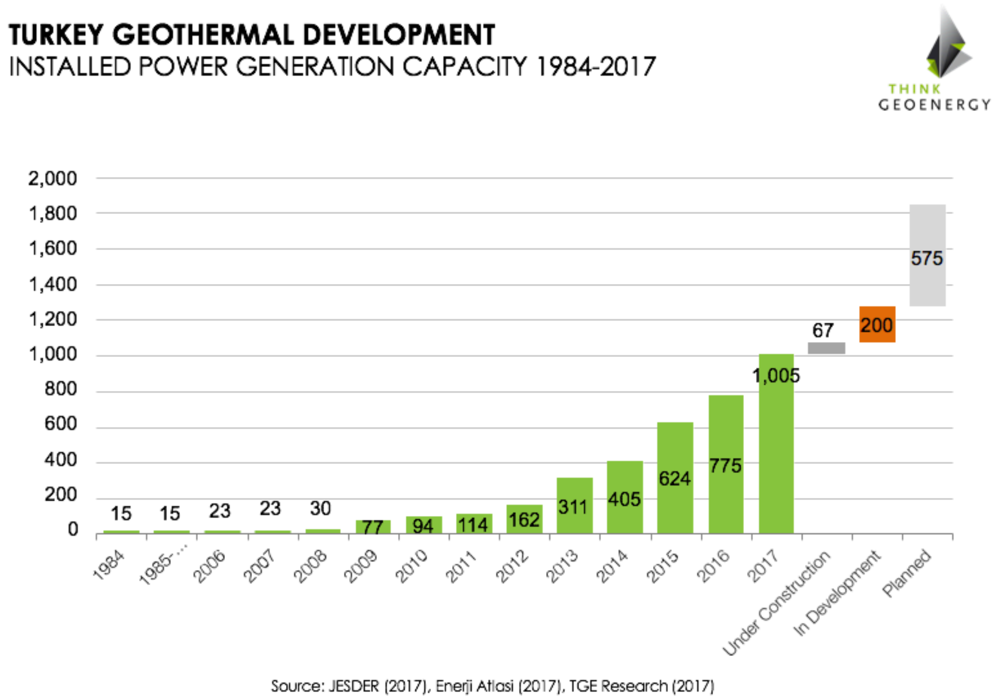


Rather than pointing to Iceland as an example of why not to develop geothermal, we should point to the United States as an example of why we should. It is not a question of lack of resources holding back geothermal development in BC, but political will, which goes beyond what BC Hydro can alone provide.

For another example, look to Turkey to see how a nation can swiftly yet effectively develop geothermal electricity when regulators and politicians are committed to the cause. Turkey is a large country, similar in size to BC, which also possesses varied geothermal resources just as BC is expected to.

Additionally, most geothermal plants in Turkey are located in one quadrant of the country and therefore represent a similar regional concentration to both the United States and Canada in terms of geothermal potential**.**

Chart 3:



Note how Chart 3 (above) illustrates a skyrocketing geothermal capacity in Turkey once government and regulators got on board. Policies and regulations friendly to geothermal development, plus found resources, equals a thriving geothermal industry.

"Exploration to Date in BC Has Not Identified Any Viable Geothermal Resources":

CanGEA refers the Panel to subsequent sections in this submission, as well as our initial submission of August 30, 2017, as well as the many reports freely available on the CanGEA website in refutation of this assertion. There are numerous sites across British Columbia that hold remarkable potential for geothermal development. Some, like the Canoe Reach project near Valemount, or the Lakelse Lake project near Terrace, have proceeded to the drilling stage.

CanGEA looks forward to helping BC Hydro develop a full and complete understanding of the geothermal industry and its potential. But it is important to note that once that happens, BC Hydro would still be largely unable to help because of a lack of policy and regulatory support. BC Hydro will need the dedication of the British Columbia Ministry of Energy, Mines and Petroleum Resources and the BC Government at large, to realize the potential of geothermal electricity in BC.

CanGEA requests that the British Columbia Utilities Commission recommend that the Government of British Columbia do its part to help establish the geothermal industry. BC Hydro can't do it alone.

Response to BC Hydro Submission of September 22, 2017:

In their submission to the Commission on September 22, 2017, BC Hydro inquired as to costs they believed were missing from the calculations of alternative resource costs in the second report prepared for the Commission by Deloitte LLP.

We concur with BC Hydro's assessment that the approximate capital cost of ~95MW of geothermal electricity would be $5,200/kW or $5.2MM/MW, as this number roughly corresponds to our own calculations. In our discussion of the Deloitte report in Appendix D of this submission, we point out that Deloitte concluded that a portfolio of renewable sources including geothermal would be similarly cost-effective to Site C, but that Deloitte made use of Geoscience BC's data to come to this conclusion. Therefore, given the many cost-inflating flaws with Geoscience BC's data, we also point out that in fact a portfolio of renewable sources that included geothermal would be even more cost-effective than Deloitte calculated. BC Hydro's calculation that the capacity cost for geothermal is closer to $5.2MM/MW than Deloitte's range of $7.3MM/MW to $8.8MM/MW bears out our belief in the cost-effectiveness of geothermal.

BC Hydro also requested clarification on the inclusion of transmission, road, and similar costs for capital costs, as well as the inclusion of trade impacts or carbon taxes in operational costs. BC Hydro’s confusion on this point is understandable given that Geoscience BC’s cost assessments almost completely ignored road costs (see Table 6-3, on page 20 of this submission, taken directly from Geoscience BC’s 2015 Report. CanGEA cannot speak directly to the costs of non-member projects, but in the case of the Canoe Reach and Lakelse Lake projects, both transmission and road costs are negligible due to both projects’ locations. Both Canoe Reach and Lakelse Lake are located on pre-existing transmission lines and road systems. None or very little additional road or transmission line construction is necessary. Therefore the road and transmission costs for these projects are very low.

The proposed location of the Canoe Reach facility has power line and road access already and would not be subject to multimillion-dollar access requirements. A CanGEA member is currently working with local contractors to finalize exact costs to interconnect, but estimate it to be <$1MM. In the photograph below, the star represents the future facility location.

The location for the power facility at the Lakelse property is located within 1 km of major transmission infrastructure and within 3 km of the Skeena Substation (TER 25F562). There are local distribution power lines and road access to the proposed power plant location.

BC Hydro provided, in a Basic Distribution Study, the following comment:

> "From the POI [Point of Interconnection] to the closest BC Hydro station, there is approximately zero km of single phase line that would require upgrading to 3-phase for this interconnection. There is also the likelihood that 0.1 km of 3-phase line will need to be reconductored to accommodate this interconnection."

A thorough breakdown of the capital costs for Canoe Reach and Lakelse Lake can be found in this submission, as well as CanGEA's submission of August 30, 2017.

Furthermore, there is no trade impact or carbon tax exposure for either project. The electricity generating aspect of the project has no carbon tax exposure, and the heat generated as a by-product can be used for myriad purposes, substituting for fossil fuel heating. As a result, it acts as a carbon offset and decreases net carbon emissions. See Appendix B, point 1, in this submission, for a discussion of heat by-product as an ancillary benefit of geothermal development.

How much has BC Hydro spent in the last 15 years in exploratory drilling for geothermal resources?

We believe this number to be zero ($0).

Please explain whether there has been (or is expected to be) a significant reduction in drilling costs compared to those assumed in the 2015 Geoscience BC Report, and how this could affect both the probability of locating economic reserves by 2025/2035 and/or the cost of those reserves.

Takeaway: There has been, and is likely to continue to be, a significant reduction in drilling costs compared to those assumed in the Geoscience BC Report. Reduced drilling cost increases the probability of locating economic reserves.

(A) Reduction in Drilling Costs:

A comprehensive discussion of CanGEA's objections to the 2015 Geoscience BC Report can be found in Appendix A to this submission. The following input variables were found by CanGEA to be highly questionable, and in some cases outright misleading:

Unnecessarily Conservative Exploration and Confirmation (Test Drilling) Costs:

The authors of the Geoscience BC report have failed to comprehend either modern exploration practices or their cost structure. Current costs to explore multiple options, including failures, are cited by our members to be <$5 MM. Central to this is the use of slim hole technology, which can now reach depths of 2,500 m at a fraction of production well costs.

Exploration costs in the Geoscience BC report assume that 2 well sites are evaluated and that exploration drilling occurs at both of these sites, and that 1 exploration well is drilled at each site. This resulted in $7.1 MM per site in pre-confirmation drilling exploration costs.

In addition, the model input also assumes that confirmation drilling occurs at both sites for each project, and that only one is successful in each case. Moreover, priced into the economic model is also the assumption that 2 full-sized wells are drilled at each unsuccessful site at a cost of $9.8 MM per well. This amounts to about $20 MM spent at each unsuccessful site, which is included in the LCOE for the successful project. $9.8 MM x 2 well sites + $7.1 MM per site = $26.7 MM of additional costs, the vast preponderance of which can be done with slim hole technology at a much lower cost.

Production Wells:

Next, by way of comparison, the cost estimate for a single confirmation or production well with the Geoscience BC data set was a minimum of $5.0 MM, to as much as $11.9 MM. The actual data set from drilling programs in 2007/2008 from an Oregon geothermal developer (drilling hard basalt rock formations) ranged from $USD1.9 MM to $USD5.1 MM for full size production and injection wells. As geothermal drilling programs may have significant variability associated with depth of drilling (and therefore overall drilling costs), it is helpful to calculate drilling costs on a $/meter analysis. Based on drilling costs for the depth of wells, the Geoscience BC report estimated ~$4,000/m. The Oregon project developer's actual data was $USD2,200/m to $USD2,400/m.

One possible reason for this discrepancy is that Geoscience BC calculated the drilling costs in 2007-2008, when drilling services were at a premium due to Domestic Crude Oil Prices reaching >$90/Barrel (although the Oregon developer was still able to drill at a lower cost than what Geoscience BC suggests, even in this high cost market). The recent downturn in oil commodity pricing has also significantly impacted the costs of drilling, with oilfield operators seeing a reduction of drilling costs of 20-40% as a result of many idle rigs in competition for fewer exploration/drilling programs. In the Western Canada oilfield industry, there have been many rounds of cost cutting, layoffs, and pressure on oilfield service providers, resulting in significant cost savings for project developers.

Vastly Overestimated Production Well Costs:

The Geoscience BC Report estimates the cost of a 2,500 m production well to be $10 MM. Whereas CanGEA's recent independent estimates produce a cost of $4.5 MM, as derived from two local quotes that received third party review and have a 20% contingency. The Geoscience BC report's costs are over 115% higher than expected industry costs, in the hydrothermal geological environment of BC, such as Canoe Creek near Valemount.

The estimated cost of wells in the Geoscience BC report is of serious concern as the model input variables were not utilized correctly. GETEM allows the use of generic drilling cost curves based on historic geothermal well data in 2004 US Dollars. In the version of the GETEM model used, the modeller can choose between a "Low," "Medium," or "High" cost curve. Costs are updated to the current year (2015 in this case) using multipliers derived from the US Bureau of Labor Statistics Producer Price Index for drilling.

There are very serious concerns that arise from the manner in which well cost inputs were utilized. First, the model uses the "High" drilling cost curve without justification given the current and expected future market for drilling services in Canada. Second, a "user adjusted" multiplier that ranged from 1.18 to 1.29 is applied, further increasing the well cost.

Then there is the use of the then-current Canadian-US exchange rate, when much of the necessary services could be provided by Canadian companies and priced in Canadian dollars. This additional cost is not consistent with actual Canadian drilling costs, even excluding the recent downturn in drilling and service prices arising from the global oil price drop.

When the model was re-run with expected Canadian priced drilling services, a significantly lower Levelized Cost of Electricity (LCOE) was produced than those derived by the Geoscience BC report.

Failure to Recognize HSA Specific Drilling Costs:

The report suggests that a 2,000 m HSA production well in Northeast BC costs $8 MM ($9.6 MM for a confirmation well). This value is far removed from current market conditions. Local costs can be referenced but they are most likely already available to Geoscience BC, who is an active researcher in this area. To achieve the costs used in the model requires actively ignoring already known data and it is unclear whether Geoscience BC provided their consultants with this information to use.

The GETEM model inputs utilized are inappropriate for calculating HSA project costs. Unlikely HSA scenarios were chosen that ignored the economies of scale present in clustering multiple HSA projects, and the GETEM model is also unwarrantedly punitive with regards to drilling costs for HSA projects, which are more comparable to oil & gas drilling costs.

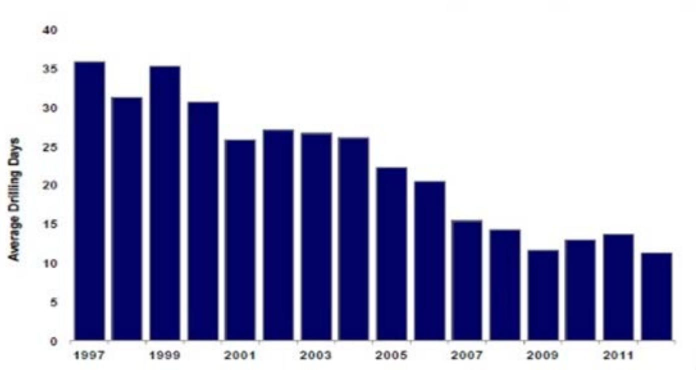
Hydrothermal geothermal projects are much more technically intensive in terms of drilling requirements, and therefore tend to have higher costs. Moreover, they tend to be carried out on greenfield sites where little previous exploration has occurred. In the case of BC's HSA resources, accurate previous drilling data exists from the oil & gas industry, and in addition its geologic environment is much more conducive to lower cost drilling.

Another relevant concept driving drilling costs are the recent advances in drilling time, where increases in the ROP (rate of penetration), in terms of meters drilled/rig day have had a significant impact in reducing the overall drilling cost.

Figure 1 below shows one example of the amount of time taken to drill oilfield wells to a 3 km depth, a reduction to less than half the time over a 15-year period. This reduction incorporates the use of more technologically advanced directional drilling. This 15-year time span shows drilling days moving from 30-35 day in 1997 to less than 15 days in 2011, and costs have continued to decline to this day.

Dialogue with leading-edge drilling companies in Western Canada state the number to be <12 days in 2017, and this is well aligned with drilling costs estimates from other global geothermal projects including recent drilling (Spring 2017) performed by an Oregon geothermal developer. Due to current oilfield market conditions and an abundance of idle rigs in Western Canada, there is currently an opportunity to use some of the best drilling companies and expertise in Canada, which may not have been available from 2008-2014 for the emerging BC geothermal industry.

Figure 1:



Average drilling days per well in the Western Canadian Sedimentary Basin [WCSB]. All 3,000m horizontal wells from 1997 - 2012 (excluding Oil Sands).[5]

Unnecessary Contingency Costs:

The overly conservative estimates mentioned above, particularly inflated well costs, cast doubt on the justification of including a 15% contingency addition to the LCOE numbers derived from the model.

In practically every instance possible, excessive contingencies were added to model variables, in the form of overly conservative inputs. This practice clearly negates the need to use a contingency, and in CanGEA's view is a questionable practice on the part of the report's authors. This approach amounts to double counting without justification.

Given the above, CanGEA is confident that well costs are less expensive than stated by the Geoscience BC report.

(B) Probability of Locating Economic Reserves:

If the drilling process is less expensive, it drives down the overall capital cost. The probability of locating economic reserves increases because those believed to be overly expensive can be explored with low drilling costs.

If BC Hydro were to accelerate the development of the geothermal industry in BC by undertaking additional exploratory drilling, please estimate the size of the budget that would reasonably be required.

Takeaway: The budget for any combination of geothermal projects can be calculated based on the ESMAP standard.

ESMAP refers to the Guidelines of the World Bank Energy Sector Management Assistance Program, and is considered a reliable international standard.

[5] geoSCOUT, ARC Financial Research.

Observe Table 1 below, an excerpt of the full capital cost table (Table 3) prepared for CanGEA by Dewhurst Group LLC that is presented in full on page 18 of this submission. Credentials for Dewhurst Group LLC may be found in Appendix E of this submission.

This is a sample of sites with geothermal potential across British Columbia, in which BC Hydro could participate in order to accelerate the development of the geothermal industry in BC. The arrow indicates the column containing site potential data derived from Geoscience BC's Report, with the exceptions of Canoe Creek and Lakelse Lake as described by the asterisks.

Table 1:
COST & POTENTIAL OF SELECT BC GEOTHERMAL SITES

Geoscience BC's Data

Site Name	P90 Site Potential (MWe)	High Estimated Site Cost from ESMAP (USD$MM/MWe)	High Estimated Total Site Cost (USD$MM)	Geothermal Development Phases per ESMAP		
				Pre-Survey-0.5% (USD$MM)	Exploration-1.5% (USD$MM)	Test Drilling-18% (USD$MM)
Clarke Lake	20.0	5.5	110.0	**0.6**	**1.7**	**19.8**
Jedney Area	15.0	5.5	82.5	**0.4**	**1.2**	**14.9**
Kootenay	20.0	5.5	110.0	**0.6**	**1.7**	**19.8**
Lower Arrow Lake	20.0	5.5	110.0	**0.6**	**1.7**	**19.8**
Meager Creek	100.0	5.5	550.0	**2.8**	**8.3**	**99.0**
Mt. Cayley	40.0	5.5	220.0	**1.1**	**3.3**	**39.6**
Okanagan	20.0	5.5	110.0	**0.6**	**1.7**	**19.8**
Lakelse Lake	23.2*	5.5	127.5	**0.6**	**1.9**	**23.0**
Canoe Reach	58.0*	5.5	319.0	**1.6**	**4.8**	**57.4**
Lakelse Lake	23.2*	4.15**	97.4	**0.5**	**1.5**	**17.5**
Canoe Reach	58.0*	4.15**	243.6	**1.2**	**3.7**	**43.8**

* Site potential data derived not from Geoscience BC, but rather from actual CanGEA members' project results measured during site development.
** Estimated Site Cost factor reduced by Dewhurst Group LLC to adjust for exploration results already confirmed.

The budget for any combination of projects BC Hydro prefers to participate in could be easily calculated from Table 1 above. Site cost factor for the Lakelse Lake and Canoe Reach projects has been reduced to 4.15 from 5.5 to account for the work already done on those projects (pre-survey and partial exploration have already been completed and the test drilling stage is in progress).

Do the capital costs as provided by the Canadian Geothermal Association also include exploration costs?

Takeaway: Yes. Capital cost data derived from the Geoscience BC Report, as well as from CanGEA's own members' projects, all are inclusive of exploration costs.

If the Panel is referring to capital costs used by CanGEA in calculations by Dewhurst Group LLC to calculate the viability of the Canoe Creek and Lakelse Lake projects, those numbers also include exploration costs, as shown in the full cost breakdown in Table 3 below.

Table 3 represents Geoscience BC MW estimates, and ESMAP development costs. For Canoe Creek and Lakelse Lake, the estimated site cost factor is reduced from 5.5 to 4.15 to account for the work already done on those projects.

To be absolutely clear, the capital cost is broken down fully in Table 3 and contains:

- **Pre-Survey costs (the subject of this question),**
- **Exploration costs (the subject of this question),**
- **Test Drilling costs (the subject of this question),**
- Feasibility Study Planning costs,
- Drilling costs,
- Construction costs,
- Start-up Costs, and
- First Year Operation and Maintenance costs.

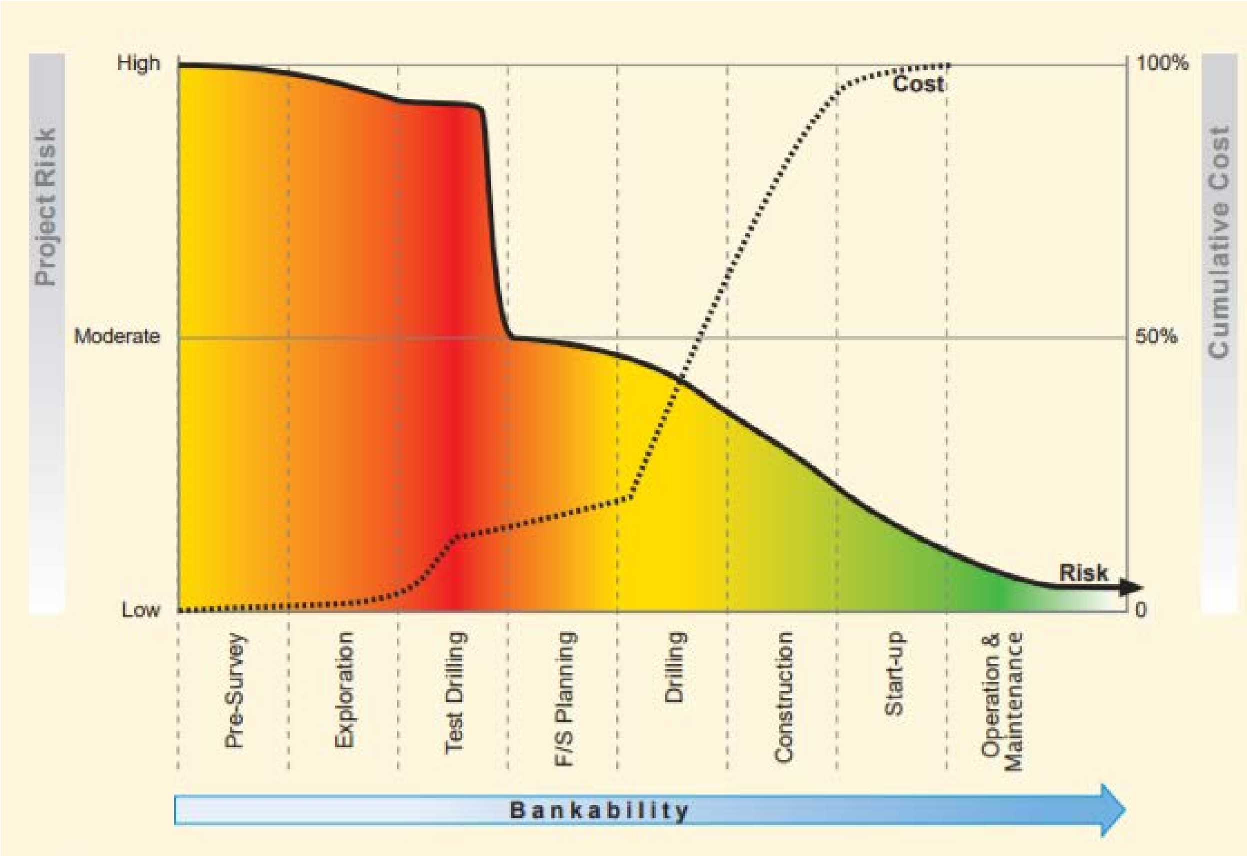
Table 3:

Site Name	P90 Site Potential (from Geoscience BC) MWe	High Estimated Site Cost (from ESMAP) USD$MM /MWe	High Estimated Total Site Cost (from ESMAP) USD$MM	Geothermal Development Phases per ESMAP							
				Pre-Survey 0.5% USD$MM	Exploration 1.5% USD$MM	Test Drilling 18% USD$MM	F/S Planning 5% USD$MM	Drilling 45% USD$MM	Construction 20% USD$MM	Start-Up 5% USD$MM	Operation and Maintenance 5% USD$MM
Clarke Lake	20.0	5.50	110.0	0.6	**1.7**	19.8	5.5	49.5	22.0	5.5	5.5
Jedney Area	15.0	5.50	82.5	0.4	**1.2**	14.9	4.1	37.1	16.5	4.1	4.1
Kootenay	20.0	5.50	110.0	0.6	**1.7**	19.8	5.5	49.5	22.0	5.5	5.5
Lower Arrow Lake	20.0	5.50	110.0	0.6	**1.7**	19.8	5.5	49.5	22.0	5.5	5.5
Meager Creek	100.0	5.50	550.0	2.8	**8.3**	99.0	27.5	247.5	110.0	27.5	27.5
Mt. Cayley	40.0	5.50	220.0	1.1	**3.3**	39.6	11.0	99.0	44.0	11.0	11.0
Okanagan	20.0	5.50	110.0	0.6	**1.7**	19.8	5.5	49.5	22.0	5.5	5.5
Lakelse Lake	23.2*	5.50	127.6	0.6	**1.9**	23.0	6.4	57.4	25.5	6.4	6.4
Canoe Reach	58.0*	5.50	319.0	1.6	**4.8**	57.4	16.0	143.6	63.8	16.0	16.0
Lakelse Lake	23.2*	4.15**	96.3	0.5	**1.4**	17.3	4.8	43.3	19.3	4.8	4.8
Canoe Reach	58.0*	4.15**	240.7	1.2	**3.6**	43.3	12.0	108.3	48.1	12.0	12.0

* Site potential data derived not from Geoscience BC, but rather from actual CanGEA members' project results measured during site development.
** Estimated Site Cost factor reduced by Dewhurst Group LLC to adjust for exploration results already confirmed.

Chart 4 (below), provided to CanGEA by Dewhurst Group LLC, shows a percentage breakdown from ESMAP (2012) regarding the projected cost vs. risk analysis of a typical geothermal development.

Chart 4:



Project Cost vs. Risk Profile (Taken from ESMAP, 2012).

If, instead, the Commission is referring to capital costs used in our initial submission outside of the Dewhurst Group LLC calculations, CanGEA used capital cost data from Table 6-3 of the 2015 Geoscience BC Report (below). These capital costs included exploration costs, as indicated by the blue arrow.

Table 6-3: Estimated Capital Costs for Favourable Sites

Geothermal Prospect Area/Site	Transmission-Line Costs (incl. Substations) (million CAD$ 2015)	Road-Building Costs (million CAD$ 2015)	Permitting & Leasing Costs† (million CAD$ 2015)	Resource Exploration Costs** (million CAD$ 2015)	Resource Confirmation Costs†† (million CAD$ 2015)	Resource Development Costs*** (million CAD$ 2015)	Power Plant Costs (million CAD$ 2015)	Total Capital Costs (million CAD$ 2015)	Total Cost per Gross kW Installed (CAD$ 2015)
Canoe Creek – Valemount	$16.4	-	$0.5	$13.0	$45.2	$50.7	$43.8	$169.6	$11,900
Clarke Lake	$14.4	-	$0.5	$15.9	$52.6	$54.0	$67.3	$204.7	$11,100
Clarke Lake (5 MW scenario)	$1.5	-	$0.5	$5.3	$16.5	$19.6	$19.3	$62.8	$12,600
Jedney Area	$34.5	-	$0.5	$10.6	$36.3	$42.1	$45.3	$169.3	$13,900
Kootenay	$10.2	-	$0.5	$10.6	$33.1	$45.7	$72.7	$172.8	$8,700
Lakelse Lake	$12.2	-	$0.5	$10.6	$33.1	$44.5	$72.1	$173.0	$8,800
Lower Arrow Lake	$13.7	-	$0.5	$10.6	$33.1	$44.9	$71.6	$174.4	$8,900
Meager Creek	$13.2	$1.0	$0.5	$30.0	$85.9	$262.9	$172.5	$566.0	$5,700
Mt. Cayley	$30.6	-	$0.5	$10.6	$33.1	$79.8	$110.0	$264.7	$6,500
Pebble Creek	$6.8	$0.5	$0.5	$28.0	$85.9	$262.9	172.5	557.1	$5,600
Okanagan	$12.3	-	$0.5	$10.6	$33.1	$41.5	$67.0	$165.1	$9,000
Sloquet Creek	$2.1	-	$0.5	$7.0	$22.9	$21.0	$28.6	$82.1	$8,200

* Also includes the Jedney Area, and Clarke Lake at 5 MW
† Permitting and leasing costs are for entire project life, including environmental studies.
** Resource Exploration Costs comprise primarily slim-hole drilling costs, as well as costs for geological, geochemical, and geophysical studies.
†† Resource Confirmation Costs include confirmation drilling and well testing costs.
*** Resource Development Costs comprise wells drilled between resource confirmation and plant start-up, as well as production and injection pipelines in the wellfield.

CanGEA took Geoscience BC's capital cost estimates and used them to create Table 2, below. CanGEA created the two rightmost columns, indicated by the letters "A" and "B", to depict how Geoscience BC's cost estimates were multiples higher than the global Energy Sector Management Assistance Program (ESMAP) standard. But for the purposes of answering the Panel's question, these are not relevant. Instead, observe the column "Total Capital Costs" (surrounded by the red border). Those numbers came from Geoscience BC's table, which, once again, included exploration costs.

I--------------------------------Geoscience BC data---I

Table 2:

Units in $MM	Resource Exploration Costs	Resource Confirmation Costs	Resource Development Costs	Total Exploration & Drilling	Total Capital Cost	Project MWe Total	A $/MWe Exploration	B Ratio to ESMAP Estimate
Canoe Creek	$13.00	$45.20	$50.70	$108.90	$169.60	15.0	**$7.26**	3.4
Clarke Lake	$15.90	$52.60	$54.00	$122.50	$204.70	20.0	**$6.13**	2.9
Clarke Lake 5MW	$5.30	$16.50	$19.60	$41.40	$62.80	5.0	**$8.28**	3.9
Jedney Area	$10.60	$36.30	$42.10	$89.00	$169.30	15.0	**$5.93**	2.8
Kootney	$10.60	$33.10	$45.70	$89.40	$172.80	20.0	**$4.47**	2.1
Lakelse Lake	$10.60	$33.10	$44.50	$88.20	$173.00	20.0	**$4.41**	2.1
Lower Arrow Lake	$10.60	$33.10	$44.90	$88.60	$174.40	20.0	**$4.43**	2.1
Meager Creek	$30.00	$85.90	$262.90	$378.80	$566.00	100.0	**$3.79**	1.8
Mt. Cayley	$10.60	$33.10	$79.80	$123.50	$264.70	40.0	**$3.09**	1.4
Pebble Creek	$28.00	$85.90	$262.90	$376.80	$557.10	100.0	**$3.77**	1.8
Okanagan	$10.60	$33.10	$41.50	$85.20	$165.10	20.0	**$4.26**	2.0
Sloquet Creek	$7.00	$22.90	$21.00	$50.90	$82.10	10.0	**$5.09**	2.4
ESMAP Medium Estimate MM	**$3.00**	**$18.00**	**$86.00**	**$107.00**	**$196.00**	**50.0**	**$2.14**	**1.0**

As these tables and charts demonstrate, the capital costs used by CanGEA throughout our submission of August 30, 2017, were comprehensive and included exploration costs. Further, the capital cost information provided in the ThinkGeoEnergy bar charts in the BC Hydro October 5, 2017 question response, depict a total cost of development of $USD 3.5 MM/MW, which is a well accepted global average value. The ESMAP numbers CanGEA have provided in this submission refer to the High ESMAP case, in order to be conservative.

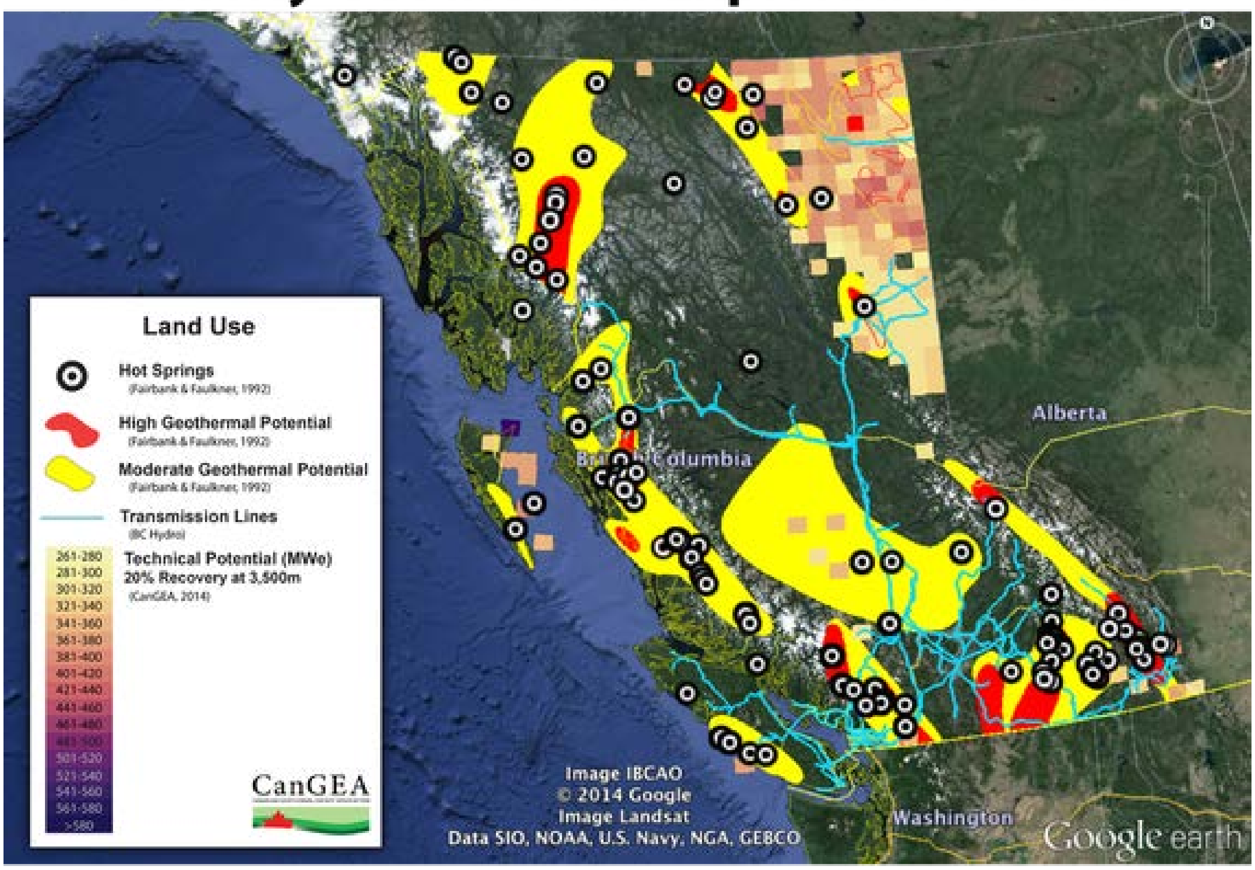
Please estimate the probability that, (i) by 2025, and (ii) by 2035, BC Hydro would reasonably be able to locate 200 MW of cost-effective geothermal energy if BC Hydro were to develop the resource partnership with industry.

Takeaway: The probability is very high, especially if CanGEA member projects at Canoe Reach and Lakelse Lake are included in an industry partnership. These projects should move ahead with government support regardless of the Site C decision, because of their additional ancillary benefits.

There are geothermal resources all over British Columbia waiting to be developed. Note Map 3 (below) produced by CanGEA, estimating BC's geothermal resources.[6]

Map 3:

Priority Geothermal Exploration Areas



The two geothermal projects being developed in British Columbia by CanGEA members are by themselves sufficient to very nearly reach the 200 MW asked for by the Panel. We believe the

[6] http://www.cangea.ca/bc-geothermal-resource-estimate-maps.html

probability of reaching 200 MW over a variety of projects, both CanGEA members' and others yet undeveloped, is very high, based on the following. (Further information is provided in Appendices F and G.)

Independent assessment of the Canoe Reach site by Dewhurst Group LLC, using standard heat-in-place stochastic methods, reveals the Canoe Reach reservoir may generate (at P90, or 90% probability to be the minimum electricity generated) 58 MWe of continual (gross) electricity (flash or binary plant) over a 30-year span. The P50 figure is 139 MWe over a similar timespan. The P10 figure is 295 MWe over a similar timespan. Guidelines of the World Bank Energy Sector Management Assistance Program (ESMAP) suggest that the MW produced at P90 are likely to have an average development cost of USD$240 Million.

Lakelse Lake, located near the town of Terrace, BC, is another example with significant potential for electricity generation. Independent assessment of the reservoir by Dewhurst Group LLC, again using standard heat-in-place stochastic methods, expects the reservoir to be able to achieve a P90 figure of 23 MWe of continual (gross) electricity over a 30-year span. The P50 figure is 54 MWe. The P10 figure is 113 MWe. The project could produce P90 MW at an approximate average development cost according to ESMAP guidelines, of USD$96 Million.

The following summarizes the findings of these P90 assessments:

Canoe Reach, at a cost of CAD$300 Million[7] for 58 MW, has an installed capital of approximately CAD$5.1MM/MW for a 95% capacity factor.

Lakelse Lake, at a cost of CAD$120 Million[8] for 23 MW, has an installed capital of approximately CAD$5.2MM/MW for a 95% capacity factor.

For illustrative purposes that mirror an expected Electricity Purchase Agreement timeframe, CanGEA has chosen a 30-year notional project life for each of the Site C and the Canoe Reach geothermal projects. Next, the gross MWh delivered is calculated, taking into consideration the capacity factors of each project. This leads to 153,212,400 MWh for Site C, 14,480,280 MWh for Canoe Reach, and 5,726,448 MWh for Lakelse Lake.

These values are then divided by total capital cost to calculate the ratio of capital cost per MWh produced.

At a capital cost of CAD$300 Million, Canoe Reach has an approximate capital cost to generation ratio of CAD$20.7/MWh.

At a capital cost of CAD$120 Million, Lakelse Lake has an approximate capital cost to generation ratio of CAD$20.9/MWh.

[7] Based on 1.25 USD-CAD conversion rate, current as of August 28, 2017. CAD$300 = USD$240
[8] Based on 1.25 USD-CAD conversion rate, current as of August 28, 2017. CAD$120 = USD$96

Three key points follow from the analysis above:

1. At the P50 level, CanGEA members have **already** located, with independent third party verification, ~200 MW of geothermal capacity within British Columbia (At the P50 level, the Canoe Reach and Lakelse Lake projects added together could produce 193 MW). This threshold is exceeded if the additional projects being pursued by non-CanGEA members are included in the analysis.
2. The geothermal capacity noted in (1) is cost effective, with capital costs in the range of CAD$20-21/MWh.
3. It would be reasonable to expect that BC Hydro could locate this capacity immediately, were it to create some form of partnership with the independent developers who have already explored for and identified geothermal resources within the Province of BC.

However, CanGEA wants to further expand its answer on this, as we may be interpreting the BCUC Panel's question too narrowly, specifically that by "locate" and "… to develop in partnership with industry" the Panel is asking the question as to when ~ 200 MW of geothermal capacity could come online in the Province of BC, with BC Hydro's active support.

Consultation with the member companies, local drillers, key equipment vendors, and regulators suggest that a careful stepwise approach with consistent annual capacity additions is likely the best and most efficient mechanism for delivering a successful geothermal development program.

In our view, it would be reasonable to suggest that, from the existing identified locations, ~40 MW_e of geothermal capacity could be brought on stream, each year, starting in 2020 and ending in 2024. This would suggest that by close of 2024, ~200 MW of geothermal capacity could be online and actively generating power.

If we consider this as being achieved by developing the resources at Canoe Reach and Lakelse Lake, then observe the following Table 4, an excerpt of selected sites from Table 3 on page 18:

Table 4:
COST & POTENTIAL OF SELECT BC GEOTHERMAL SITES, WITH BREAKDOWN COSTS OF INITIAL PHASES

Site Name	P90 Site Potential (MWe)	High Estimated Site Cost from ESMAP (USD$MM/MWe)	High Estimated Total Site Cost (USD$MM)	Geothermal Development Phases per ESMAP		
				Pre-Survey-0.5% (USD$MM)	Exploration-1.5% (USD$MM)	Test Drilling-18% (USD$MM)
Clarke Lake	20.0	5.5	110.0	**0.6**	**1.7**	**19.8**
Jedney Area	15.0	5.5	82.5	**0.4**	**1.2**	**14.9**
Kootenay	20.0	5.5	110.0	**0.6**	**1.7**	**19.8**
Lower Arrow Lake	20.0	5.5	110.0	**0.6**	**1.7**	**19.8**
Meager Creek	100.0	5.5	550.0	**2.8**	**8.3**	**99.0**
Mt. Cayley	40.0	5.5	220.0	**1.1**	**3.3**	**39.6**
Okanagan	20.0	5.5	110.0	**0.6**	**1.7**	**19.8**
Lakelse Lake	23.2*	5.5	127.5	**0.6**	**1.9**	**23.0**
Canoe Reach	58.0*	5.5	319.0	**1.6**	**4.8**	**57.4**
Lakelse Lake	23.2*	4.15**	97.4	**0.5**	**1.5**	**17.5**
Canoe Reach	58.0*	4.15**	243.6	**1.2**	**3.7**	**43.8**
TOTAL MWe	**316.2**					

* Site potential data derived not from Geoscience BC, but rather from actual CanGEA members' project results measured during site development.
** Estimated Site Cost factor reduced by Dewhurst Group LLC to adjust for exploration results already confirmed.

If BC Hydro participated in the P90 test drilling stage, already in progress at Canoe Reach and Lakelse Lake, they would be contributing to an approximate cost of $43.8MM (USD) and $17.5MM (USD), respectively. As noted previously, the site cost factor is reduced to 4.15 for these sites due to the exploration results already concluded.

It is important to note that stepwise development of a reservoir allows for much more efficient and cost effective confirmation of the incremental resource capacity for follow on tranches of build out. This would suggest some conservatism in the capital costs related to the full build out of these projects.

CanGEA enthusiastically invites BC Hydro to consider participating in funding the 2018 drilling stage for its members' projects.

It is important to note that BC Hydro could select any combination of the above sites to participate in developing and reasonably reach a total of 200 MW.

However, it is CanGEA's view that BC Hydro should understand that Geoscience BC's initial estimates of these sites' MW potential could be understated. An independent review of the Geoscience BC estimates was performed by Dewhurst LLC for CanGEA, and it leveraged geologic learnings of the Surface Area parameter from the Canoe Reach and Lakelse Lake exploration activities and how they related to Geoscience BC's resource predictions. (Dewhurst included an understanding of what within the Geoscience BC values might be likely to change given additional geophysics and geology exploration activities. The Area is a very sensitive parameter.)

This additional information allows a recasting of the P90 resource potential as initially enumerated on Table 3 on page 18.

Table 5: Comparison of Estimated Geothermal Resource Potential (selected sites)

Site Name	Original Geoscience BC Estimated P90 Site Potential (MWe)	Dewhurst Group LLC Adjusted P90 Site Potential Scenario (MWe)
Clarke Lake	20.0	**60.0**
Jedney Area	15.0	**41.0**
Kootenay	20.0	**65.3**
Lower Arrow Lake	20.0	**62.0**
Meager Creek	100.0	**87.4**
Mt. Cayley	40.0	**128.4**
Okanagan	20.0	**60.3**
Lakelse Lake	20.0	**23.2**
Canoe Reach	15.0	**58.0**
Total	**270.0**	**585.6**

CanGEA would suggest that the additional recent exploration information from 2 properties (Canoe Reach and Lakelse Lake) allows for not only an alternate estimate of the potential, but for the sites selected above, in aggregate, that there could be far more geothermal potential than initially believed.

In relation to the core question, CanGEA wants to highlight that geothermal resources should not only be understood through a lens examining the site specific benefits of various electrical generating options.

CanGEA believes that geothermal projects, like the Canoe Reach and Lakelse Lake projects and many others, should move ahead now, regardless of this Panel's Site C

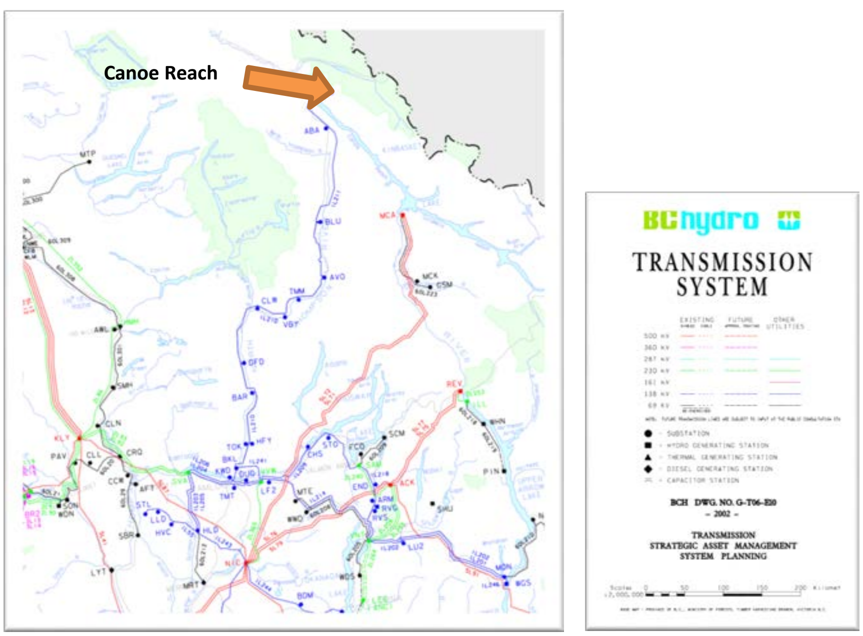
recommendation, due to the many other immediate benefits available to stakeholders such as taxpayers, ratepayers, First Nations, the economy and the environment. Geothermal energy has numerous ancillary benefits that are above and beyond electricity, and we are ready and eager to discuss them further. A full accounting of the ancillary benefits are listed in Appendix B to this submission.

Choosing only one of these benefits to use as an example below, consider the transmission cost benefits to developing these sites.

Depending upon the location of geothermal projects, they can improve BC Hydro's existing transmission network. They can help customers by improving local electricity service and reducing BC Hydro's costs in these areas. For instance, purchasing electricity from a base load project located at the end of a long radial transmission line, will improve the level of electricity service and reliability to local customers.

The Canoe Reach geothermal project is located near Valemount, at the end of a 300 km long 138 kV radial transmission line, and as a result this region is known for frequent electricity outages. Placing base load capacity near Valemount will not only secure electrical service in the region, it will also negate the need for expensive upgrades to, or expansion of, the existing transmission line. This will help reduce some pressure for BC Hydro to increase electricity rates. It will also help to avoid regional economic damages caused by brown-outs and electrical instability. A base load project would support the Valemount region's growing aggregate demand from incoming business projects such as the Valemount Glacial Destinations ski resort, currently under construction. Observe Figure 2 (below).

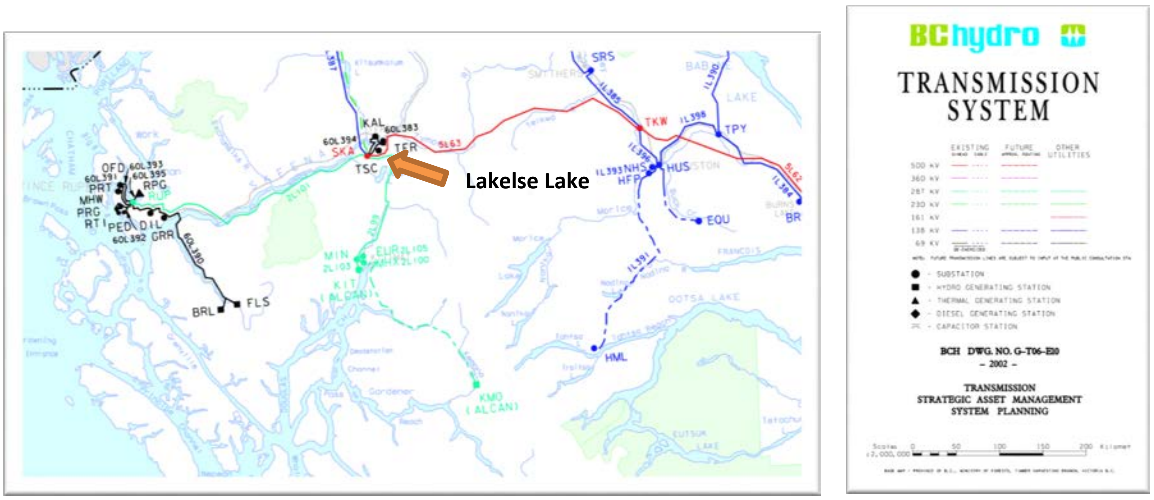
Figure 2: Adding Base Load Power to the End of the Line (Canoe Reach)



Similarly, the Lakelse Lake geothermal project near Terrace is not only poised to serve developing industrial loads, it also would reduce or eliminate line losses from Prince George through Terrace to Bob Quinn Lake.

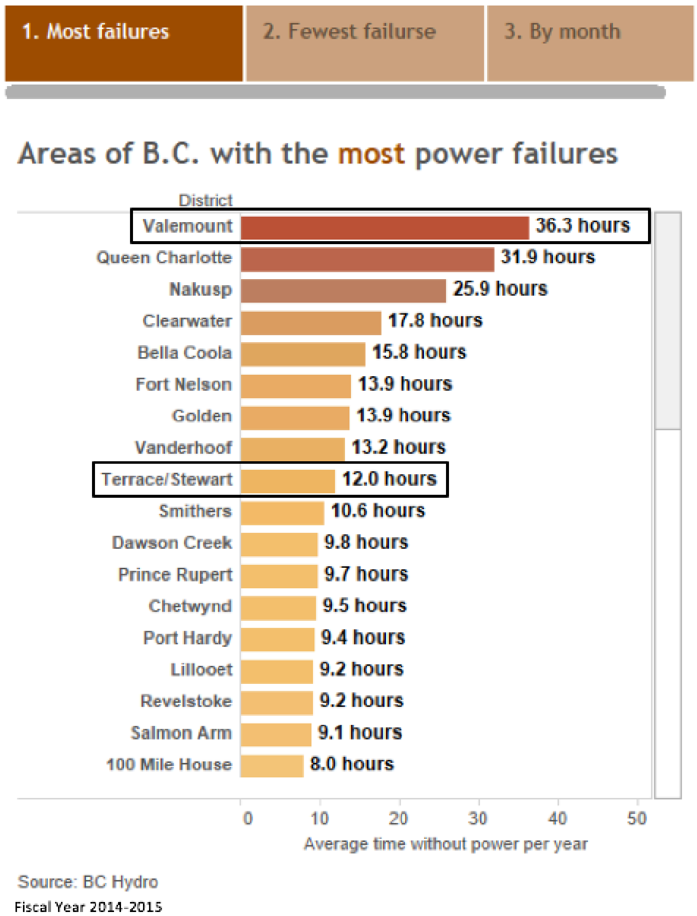
Observe Figure 3 (below).

Figure 3: Base Load Power at a Critical and Growing Junction (Lakelse Lake)



Additional geothermal resources in the province are located in similar end-of-line' scenarios.

Chart 5:



Observe Chart 5 (above), where Valemount (the location of the Canoe Reach project) is listed as the single most likely area to suffer from power failures in the Province. Terrace (the location of the Lakelse Lake project) is not far behind at number 9. Both these areas would immediately benefit from base load projects.

Project development at the Canoe Reach and Lakelse Lake sites could likely save BC Hydro ratepayers hundreds of millions of dollars by avoiding or delaying the need to build new transmission infrastructure, and mitigate loss of service to these areas.

Please provide an update of the $81/MWh ($2018) estimated cost of the two geothermal projects identified by BC Hydro (about 1300 GWh and 200 MW total) delivered to the Lower Mainland, using BC Hydro's cost of financing and current operational costs. Please provide all input assumptions used to calculate the estimated cost, and supporting calculations.

Takeaway: Meager Creek's viability has been curtailed by a 2013 landslide. We have no information on Pebble Creek.

On October 3, 2017, BC Hydro confirmed to CanGEA that these 2 locations were Meager Creek and Pebble Creek.

Mount Meager Landslide

August 6, 2010 – Destroyed all access routes to Meager Creek.

Current Status:

In 2013, Timber Licencee Squamish Mills began developing new access to Meager Creek via the South Meager Forest Service Road that has an expected completion date between 2017 and 2018.

On August 6, 2010 the Mount Meager landslide occurred, measured at 300 m wide and 2 km long containing over 48,500,00 m^3 of debris, making it the largest landslide ever in Canada. The landslide created a dam across Meager Creek and the Lillooet River, creating a lake just upstream from the blockage. Though the landslide destroyed all access routes to Meager Creek, in 2013 a timber licencee Squamish Mills began developing a new access route to Meager Creek via the South Meager forest service road, with an expected completion date between 2017 and 2018.[9]

It remains unclear if the new access road will indeed provide access to the Meager Creek geothermal project that has been cited as one of the 2 projects that may be able to provide electricity for $81/MWh in this question.

9 Cordilleran Geoscience, "The Meager and Pebble Creek Hotsprings near Pemberton, British Columbia: Guidance towards a Landslide Risk Management Plan," Report for the Ministry of Forests, Lands and Natural Resource Operations, March 17, 2017.

As the Pebble Creek project is not a CanGEA member's project, we do not have information on it to provide to BCUC.

However, 2 CanGEA member projects have applied to the BC Hydro Standing Offer Program, in 2016 and 2017 respectively. We request that the Panel consider them as well. These are the Lakelse Lake and Canoe Reach projects previously described in this submission, and our industry welcomes collaboration with BC Hydro to accurately estimate the $/MWh cost and ancillary benefit (transmission grid support) credit of these projects. We do anticipate the $/MWh costs to be materially lower than what Geoscience BC suggested in their 2015 and 2016 reports, given the promising exploration results achieved and capital cost estimates completed to date.

Conclusion:

In conclusion, we would like to reiterate our belief that a strong government commitment to geothermal development would strongly benefit BC Hydro ratepayers, BC taxpayers, First Nations, the economy, and the environment.

CanGEA recommends a basket of alternative resources, prominently featuring geothermal but by no means limited to it (although we think a basket containing exclusively geothermal is also possible).

CanGEA requests that the Commission recommend to the BC government that a CanGEA member developer be appointed to the BC Hydro and Geoscience BC boards, so that we can continue to promote understanding of the true potential of geothermal power in British Columbia.

CanGEA enthusiastically supports and welcomes BCUC's suggestion of a BC Hydro resource partnership with industry. But BC Hydro can't create the geothermal industry in BC all by itself. It will take the commitment, dedication, and direct support of the BC government to realize the potential of geothermal electricity and its associated benefits in BC.

We look forward to the new BC government stepping up and helping BC Hydro do what is best for British Columbians. A government that takes a strong stand in support of geothermal development is a government preparing to meet the needs of its people into the future.

Warm Regards,

Nathan Coles
BHum, JD
Senior Policy Manager

On Behalf of CanGEA's Policy Team

CanGEA Board Members Alex Richter (ThinkGeoEnergy) & Alison Thompson (management at Borealis GeoPower Inc. & board director at Kitselas Geothermal Inc.) contributed information to this submission.

Appendix A: Inaccuracies in the Geoscience BC Report[10]

In July 2015, Geoscience BC in support of BC Hydro's "Resource Options Update" released a report titled "An Assessment of the Economic Viability of Selected Geothermal Resources in British Columbia". The stated goal of the report was "to better understand the economic viability of geothermal energy in British Columbia" and to undertake "a high level technical and economic assessment using publicly available information for 18 unspecified geothermal sites around the province." A year later, in response to concerns raised by CanGEA and others regarding the report's veracity, Geoscience BC released a technical supplement to the report which, despite its intent to update and correct the data in the initial report, actually made the situation worse, further maligning geothermal's economic viability.

The Geoscience BC report is still relied upon, despite CanGEA and others repeatedly pointing out significant shortcomings that, in CanGEA's view, render its findings incomplete, inaccurate, and misleading. The cost estimates derived in the report are not credible representations of the true costs of power or suitability for procurement. Some problems with the report include:

1) General inapplicability of the Geothermal Electricity Technology Evaluation Model (GETEM) to derive a Levelized Cost of Electricity (LCOE) for the sites chosen in the report.
2) Improper comparison using the Standing Offer Program (SOP) as a procurement and decision-making mechanism in relation to geothermal projects.
3) Inaccurate cost inputs, including vastly overestimated well costs, high cost of capital during early project phases, unnecessary contingency costs, illogical transmission costs, unnecessarily conservative exploration costs, and lack of consideration of actually realized industry cost reductions.
4) Discount rate concerns relating to BC Hydro's failure to heed Joint Review Panel recommendations to de-risk geothermal energy projects.
5) Unwarranted exclusion of projects for lack of exploration.
6) Failure to credit transmission line savings.
7) No consideration of Hot Sedimentary Aquifer (HSA) clustering.
8) Arbitrary exclusion of off-grid projects.
9) Lack of consideration of positive externalities or alternate revenue streams.
10) Inappropriate build out periods.
11) Improper grouping of projects.
12) Discrepancy in capacity factor and project life.

These several objections make the data produced by the report highly questionable. Regrettably, the existence of this report has had a knock-on effect on geothermal development in Canada since its numbers have been cited and relied upon repeatedly since it came out. The authors of the report, for all the effort they put in, have not well positioned the geothermal industry in Canada by unfairly and inaccurately painting geothermal as overly expensive, not cost-effective, and unreliable.

[10] http://www.cangea.ca/reports--resource-material.html

Appendix B: Ancillary Benefits of Geothermal[11]

CanGEA has found there to be the following ancillary advantages to geothermal power projects. A majority of these were economic considerations:

1. Geothermal Heat is a Valuable By-Product. In many cases, this heat can be as equally or more valuable than the power generated.
2. More Permanent Jobs are Generated by Geothermal Operations Than Other Alternatives.
3. Costly BC Hydro System Transmission Upgrades are Avoided or Minimized
4. The Power Grid is Strengthened Through Geothermal Energy's Unique Base Load and Dispatchable Capacity.
5. Geothermal Fluids Create Strategically Significant Mineral and Rare Earth Elements Recovery Opportunities.
6. Geothermal Power Plants Can be Built to Meet Demand and Manage or Reduce the Risk of Cost Overruns Associated with Large-Scale Projects.
7. Geothermal Offers Increased Food Security and Price Stability.
8. The Physical and Environmental Footprint of Geothermal is Small.
9. Geothermal Offers a Means to "Green" Oil & Gas and Mining Operations.

1. Geothermal Heat is a Valuable By-Product

Geothermal resources offer a low-cost source of heat that can be utilized in addition to, or independent of, power production. Geothermal energy can be used for nearly any commercial or industrial process requiring heat. Such resources are used in 73 countries around the world to spur economic growth, and are especially suited to rural areas, Indigenous communities, and entrepreneurs. Take Valemount for example, where natural gas is not available. Instead, propane is trucked into the area and used for heating.

2. More Permanent Jobs are Generated by Geothermal Operations Than Other Alternatives

1,100 MW of geothermal power projects would create much more sustainable employment for surrounding communities. U.S. Department of Energy (DOE) statistics indicate that the amount of geothermal energy equivalent to the Site C project would produce 1,870 permanent jobs. This total does not include jobs that result from the direct use of geothermal heat, which are also significant.

3. Costly BC Hydro System Transmission Upgrades are Avoided or Minimized

Depending upon the location of geothermal projects, they can improve BC Hydro's existing transmission network. Moreover, they can help customers by improving local electricity service and reducing BC Hydro's costs in these areas. For instance, purchasing electricity from a base

[11] http://www.cangea.ca/reports--resource-material.html

load project located at the end of a long radial transmission line, will improve the level of electricity service and reliability to local customers.

An example of this is the Canoe Reach geothermal project, currently in the drilling stage, located near Valemount, BC[12]. As a result of its location at the end of a 300 km long 138 kV radial transmission line, this region is known for frequent electricity outages. Placing base load capacity near Valemount will not only secure electrical service in the region, it will also negate the need for expensive upgrades to or expansion of the existing transmission line. This will help reduce some pressure for BC Hydro to increase electricity rates. It will also help to avoid regional economic damages caused by brown-outs and electrical instability. The inclusion of a base load project would also allow Valemount to better serve and attract business projects such as the Valemount Glacial Destinations ski resort.

Similarly, the Lakelse Lake geothermal project near Terrace is not only poised to serve developing industrial loads, it also would reduce or eliminate line losses from Prince George through Terrace to Bob Quinn Lake. Additional geothermal resources in the province are located in 'end-of-line' scenarios as well.

As a third example, building geothermal projects near Fort Nelson would help electrify new industrial load. This could likely save BC Hydro ratepayers hundreds of millions of dollars by avoiding or delaying the need to build a new North-East Transmission Line, the feasibility of which is still being studied by BC Hydro but the cost of which is estimated at $1 billion.

Geothermal energy has the potential to save ratepayers and BC Hydro substantial sums, as it would delay, reduce, and/or eliminate the need to build or upgrade transmission lines.

4. The Power Grid is Strengthened Through Geothermal Energy's Unique Base Load and Dispatchable Capacity

Jurisdictions worldwide recognize the benefit to their power grids of incorporating energy sources that either have a base load capacity, or are dispatchable. The advantages accruing from such characteristics are referred to as ancillary services. Neither wind, solar nor run of river hydro possesses both of these characteristics. In contrast, geothermal power is both a base load source of energy, and is also dispatchable. Dispatchable energy sources are essentially those that can be ramped up and down by operators. While the Site C project is dispatchable to some degree, it is not able to do so as effectively as geothermal energy.

As is done in the State of California, these characteristics should be financially recognized in British Columbia. By providing dependable capacity, geothermal power has the potential to shape, firm and help integrate intermittent and other renewable sources such as wind, solar and run of river hydro onto the grid. These positive ancillary services can also be used to maximize profits from power exports. This is a policy objective of the Site C project.

[12] Think Geoenergy, Drilling for Canoe Reach Geothermal Project in British Columbia could start this year, (August 2017): http://www.thinkgeoenergy.com/drilling-for-canoe-reach-geothermal-project-in-british-columbia-could-start-this-year/

A further benefit of geothermal power production is that in colder climates, like Canada, there is the ability to generate more power output in the winter months. This matches well with the "winter peaking" electrical grid that exists within BC.

5. Geothermal Fluids Create Strategically Significant Mineral and Rare Earth Elements Recovery Opportunities

Geothermal brine contains various minerals, rare earth elements and near earth elements, which can be extracted prior to reinjection into the ground. An example of this is lithium. Lithium is a valuable material used in the production of electric vehicles. Many more minerals and elements are believed to be capable of extraction. These materials are used in the production of a variety of important technologies, including computers, mobile phones, and national defense systems. Therefore, geothermal energy's ability to enable the cost-effective extraction of such minerals and rare earth elements is strategically significant, as it can enable Canada to be self sufficient with respect to these commodities. It will also serve to enhance the cost-effectiveness of geothermal projects.

Importantly, recovery of rare earth elements can be accomplished in a manner that does not adversely impact the surrounding environment. For example, binary geothermal power plants operate in a closed loop system, so that all withdrawn groundwater is reinjected.

6. Geothermal Power Plants Can be Built to Meet Demand and Manage or Reduce the Risk of Cost Overruns Associated with Large-Scale Projects

Building costly, large-scale hydro stations that can take up to a decade to complete is a course of action that has been called into question, by such experts as London Economics International LLC. If BC needs additional power supply, technologies that have shorter lead times, with a planning framework that can be adjusted to actual demand, should be favoured. Additional geothermal electricity supply can be generated in smaller increments and closer to markets[13].

A useful byproduct of developing geothermal power plants is the fact that these plants will allow for build out in accordance with electricity demand. This will avoid risks of excess supply should expected future demand not materialize. A recent report produced for the Clean Energy Association of British Columbia (CEBC) by London Economics International (LEI), addressed these concerns at length[14].

CanGEA believes that geothermal energy's benefits are best realized through the distribution of projects throughout BC. This will help to ensure that the economic benefits of geothermal projects are felt by a broad array of BC's communities and First Nations while keeping cost overruns in check.

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[13] Marc Eliesen, *An Evaluation of the Need for the Site C Project*, (August 2017): 18.

[14] London Economics International LLC, "Cost-effectiveness evaluation of clean energy projects in the context of Site C" Report Prepared for the Clean Energy Association of British Columbia, (Vancouver, BC: September 16, 2014): 1.

7. Geothermal Offers Increased Food Security and Price Stability

Geothermal energy has the potential to increase food security in rural and Indigenous communities. Heat, which is a by-product of geothermal power plants, is utilized around the world as a source of energy for greenhouses and fish farms. These can provide affordable fresh fruits and vegetables, as well as a source of protein, while also providing jobs.

8. The Physical and Environmental Footprint of Geothermal is Small

Geothermal energy is recognized internationally as a clean and reliable power source with greenhouse gas emissions per unit of energy that are comparable to nuclear, and lower than hydroelectric.

As a case in point, the use of binary geothermal power plants are considered by most experts to be especially environmentally benign. They emit no, or nearly no greenhouse gases, and operate in a closed loop system, so that all withdrawn groundwater is re-injected. They also utilize a concentrated subterranean resource, and thus have a smaller physical footprint than nearly all other sources of energy, conventional and renewable alike.

9. Geothermal Offers a Means to "Green" Oil & Gas and Mining Operations Through the Use of Geothermal Energy

Making use of the excellent geothermal potential in northeast BC could help to avoid the emission of millions of tonnes of GHGs into the atmosphere from natural gas operations. Using distributed geothermal power plants to electrify gas fields and the proposed Liquefied Natural Gas (LNG) operations would have many advantages over a massive fixed resource with long transmission lines like the Site C project. This is especially true as distributed geothermal power plants have a high level of consistency and reliability.

As well, oil & gas operations produce large quantities of hot water, much of which is hot enough to be used for geothermal power production. Currently, much of this hot water is disposed of at great expense to the producer. The co-produced hot water can be used on-site for micro-power production, as a means of "greening" these operations by reducing the need to burn diesel or natural gas. Moreover, this can also increase the profitability of these operations.

In a similar way, geothermal water can be used in a variety of mining processes, including as a source of heat for the extraction of gold and silver through the heap leaching process.

Appendix C: Access to Reservoir Permits

One important statement by BC Hydro (in their F-1 submission to the Commission of August 30, 2017, Appendix L, p. 35) that must be directly addressed is described on page 9 of Appendix A of the Preliminary Report released on September 20, 2017. BC Hydro has stated that it has received only two applications for low-medium temperature geothermal projects (for less than 15MW) in BC Hydro's Standing Offer Program. As confirmed by BC Hydro in correspondence with CanGEA on October 3, 2017, those two sites for which BC Hydro received applications are Meager Creek and Pebble Creek.

This information is no longer accurate, as in 2016 and 2017 two additional applications were made, by the CanGEA member developers of the Lakelse Lake and Canoe Reach projects.

Further, BC Hydro's original statement is somewhat misleading, in that it doesn't fully discuss the BC government context around why there is a limited amount of geothermal development. There is a lack of a robust regulatory system in place for the BC government to issue reservoir permits to potential geothermal developers; as a result very few have been issued. It would be impossible for a developer to submit a bid to BC Hydro for a geothermal project without first obtaining rights to the land in question. Therefore almost no bids have been forthcoming. Although it is true that BC Hydro has received almost no bids from geothermal developers, this is not due solely to a lack of profitability or viability of geothermal projects.

There are several CanGEA members who are trying to develop geothermal resources in British Columbia, but are unable to do so as they do not yet have permits. There are also a handful of other developers, not yet CanGEA members, who are in a similar situation. If required, CanGEA can provide evidence of how long it takes the BC Government to process resource tender and expansion requests.

A lack of bids can be more accurately attributed to a lack of past government support, both regulatory and financially, towards the geothermal industry in British Columbia, which is waiting eagerly to be able to harness BC's vast geothermal potential.

Appendix D: The Deloitte Report

On September 8, 2017, Deloitte LLP produced an independent report for BC Hydro on Site C Alternative Resource Options and Load Forecasts. Deloitte was able to generate a portfolio of alternative-generation projects that included geothermal, and that:

- Met the energy objectives set out in the Clean Energy Act;
- Contained commercially feasible generating projects;
- Contained achievable Demand Side Management (DSM) initiatives
- Considered firming/shaping and reliability of the grid;
- Maintained 2016/17 greenhouse gas emissions.

The cost, and value, of the generated portfolio, described in detail in the Deloitte report, was roughly comparable to that provided by the Site C project.

It is important to point out that Deloitte was still able to come up with a viable model of alternative-generation resources comparable to the Site C project while using data provided by Geoscience BC, data that CanGEA has thoroughly disputed as being based on inaccurate assumptions and overinflated cost calculations for geothermal development. CanGEA's many objections to this data can be found in our Critique of BC Hydro & Geoscience BC's 2015 assessment of the viability of geothermal power as an alternative to the Site C project, freely available on CanGEA's website. Unexpectedly, Deloitte did not use our criticism of the Geoscience BC report as a reference.

These several objections make the data produced by Geoscience BC, and subsequently heavily relied upon by Deloitte LLP in their modeling, highly questionable.

Given, then, that even while relying on this high drilling cost data, Deloitte was able to construct a viable, comparable model of alternative-generation sources (a portfolio that included geothermal alongside others), this would seem to be proof of geothermal's viability and cost-effectiveness as an alternative resource to the Site C project. If more accurate data, such as that which CanGEA has made available, were used by Deloitte in their model, since CanGEA's data reveals geothermal to be even more cost-effective and reliable than Geoscience BC indicated, therefore Deloitte's ultimate conclusions would have been an alternative portfolio even more cost-effective and even more beneficial to taxpayers, ratepayers, First Nations, and businesses. If Deloitte had used CanGEA's data, rather than Geoscience BC's data, it would have discovered a portfolio of alternative resources that includes geothermal would be just as good or even better than the Site C project, as per the terms of reference of the BCUC inquiry.

Appendix E: Biography of Warren T. Dewhurst

Warren Dewhurst is a senior executive with over 40 years of experience in business management, technology, science, and engineering. As a registered professional engineer, Warren has founded several international companies, holding over 20 years of experience in Russia, Europe, and Latin America energy and technical sectors. He is also a former US commissioned officer and Chief Geophysicist for the National Oceanic and Atmospheric Administration, Coast and Geodetic Survey. Warren has received numerous professional awards for achievement and sustained superior performance including the Department of Commerce Gold and Silver medals and the Colbert Award from the American Society of Military Engineers. As founder of Dewhurst Group, LLC, an international company focusing on geothermal exploration for utility-scale electrical power plants, Warren has provided CanGEA members with his incredible research interests and statistical methods for the nonlinear inversion of geophysical data over tectonic spreading centers, hot spots and geothermal features.

Warren Dewhurst is a "Qualified Person" under the Canadian Geothermal Reporting Code for Public Reporting, a member of the Geothermal Resources Council and the Geothermal Energy Association and a member of both respective Boards of Directors.

Appendix F:

Kitselas Geothermal Inc. (KGI) recently completed a pre-feasibility study for their concession at Lakelse Lake, BC, approximately 10 km South of Terrace, BC. Subsurface temperatures, based on available geothermometry, have been estimated to exceed 150° Centigrade at a depth of approximately 2,000 m. The reservoir area has been estimated to be approximately 15 km^2 with an average thickness of 500 m. These results indicate 5,300 petajoules (PJ) of thermal energy in place may exist, relative to 15°C, that is estimated to be capable of yielding at least 23 MWe of continuous electrical power over a 30-year span. It should be noted that this geothermal system can be considered an “Inferred Geothermal Resource” in accordance with the Canadian Geothermal Reporting Code for Public Reporting ("Code") (CanGEA, 2010). Minimum subsurface information data are available. A continued surface exploration program and confirmation drilling plan that consists of drilling to a depth no more than 2 km are anticipated.

The resource estimate has been prepared in accordance with the CanGEA Code (the Canadian Geothermal Reporting Code for Public Reporting, 2010). Warren T. Dewhurst of the Dewhurst Group, LLC (DG) who is responsible for its content, prepared the pre-feasibility report. Dr. Dewhurst, the founder of DG, is a "Qualified Person" under the Code. He is both a member and serves on the Board of Directors for both Geothermal Resources Council and the Geothermal Energy Association.

Appendix G:

Borealis GeoPower Inc. (BGP) recently completed a pre-feasibility study for their concession at Canoe Reach, BC, 15 km South of Valemount, B.C. Subsurface temperatures, based on available geothermometry, have been estimated to exceed 200° Centigrade at a depth of approximately 1,000 m. The reservoir area has been estimated to be approximately 30 km^2 with an overall thickness of 500 m.

These results indicate 11,200 petajoules (PJ) of thermal energy in place may exist, relative to 15°C, that is estimated to be capable of yielding at least 58 MWe of continuous electrical power over a 30-year span. Subsurface confirmation drilling needs to take place before a more accurate understanding of the resource can be made.

It should be noted that this geothermal system can be considered an “Inferred Geothermal Resource” in accordance with the Canadian Geothermal Reporting Code for Public Reporting (CanGEA, 2010). BGP has recently performed multiple geophysical surveys including magnetotelluric, gravity and seismic surveys. These surveys, in combination with other ongoing exploratory and reservoir modelling activities, are sufficient for targeting initial test drilling sites.

The confirmation drilling plan consists of drilling up to five temperature gradient holes to depths of 200 – 1,000 m.

The resource estimate has been prepared in accordance with the CanGEA Code. Warren T. Dewhurst of the Dewhurst Group, LLC (DG) who is responsible for its content, prepared the pre-feasibility report. Dr. Dewhurst, the founder of DG, is a "Qualified Person" under the Code, a member of the Geothermal Resources Council and the Geothermal Energy Association and a member of both respective Boards of Directors.

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